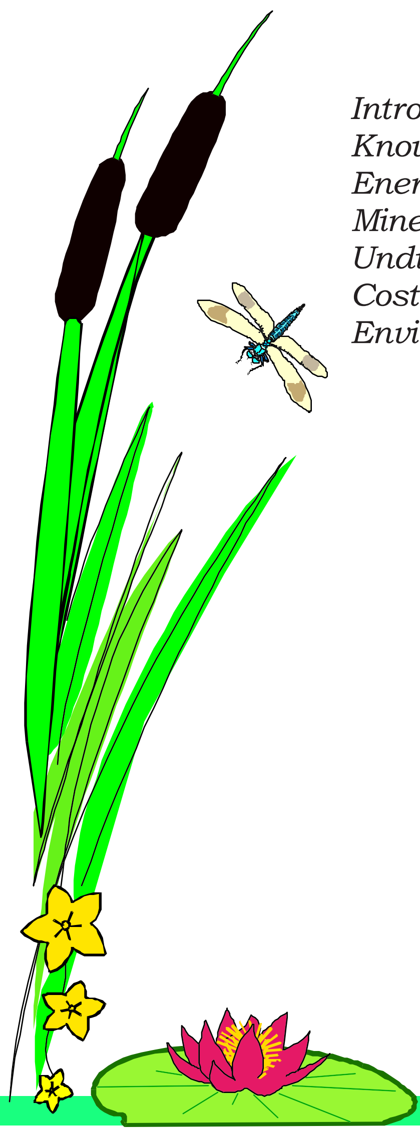
Appendix 2-3
Mineral Resources



Contents

TABLE OF CONTENTS

Introduction

A mineral resource is a naturally occurring solid, liquid, or gaseous material in or on the earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible. Identified resources are those resources whose location, grade, quality, and quantity are known or estimated from specific geologic evidence. Undiscovered resources are those resources the existence of which is only postulated, comprising deposits that are separate from identified resources. More than 20,000 sites within the Interior Columbia Basin Ecosystem Management Project area have seen mining activity. These locations show where commodities of economic interest have been found in the past and therefore outline the parts of the project area where mining activity should be expected in the future. A more specific analysis showing where significant deposits are known or resources are suspected will outline where development activity is most likely in the next 10 to 20 years.

Known Deposits

Metals and Industrial Minerals

A total of 1,065 metallic and nonmetallic mineral deposits within the project area are considered significant in terms of potential for future production. These include the 197 sites where mining activity was concentrated in 1994 as well as (1) those which are relatively large past producers and which contain additional resources or high potential for resources; (2) those which contain significant amounts of metallic or nonmetallic minerals but require more favorable economic conditions before they will be developed; and (3) those where drilling results are positive, suggesting the presence of a potentially minable deposit. Parameters considered in this designation include the deposit's type, geometry, tonnage, grade, milling or processing requirements, proximity to major population centers, proximity to transportation systems, market trends, and commodity price history.

The significant deposits, hosting a total of 19 metallic commodities and 22 industrial mineral commodities as well as rock products and energy minerals (Table 2), are summarized by state in Table 1. The deposits range in size from large to small; resources have been quantified at more than half. Although certainly significant in value of production, sand and gravel deposits are intrinsically local in importance and are not included here.

Table 1. Summary of Identified, Significant Mineral Deposits in the Project Area

State	Metallic Deposits	Industrial Minerals	Energy Minerals	Rock Products	Total Deposits
Idaho	143	100	1	13	257
Montana	174	34	None	3	211
Nevada	26	1	None	None	27
Oregon	192	72	4	32	300
Utah	3	None	None	16	19
Washington	159	56	23	6	244
Wyoming	None	4	1	None	5
Totals	**697**	**267**	**29**	**70**	**1063**

Table 2. Identified, Significant Mineral Deposits in the Project Area.

	ID	MT	NV	OR	UT	WA	WY	Total
Metallic Commodities								
Antimony	1	2	1	2	0	2	0	8
Beryllium	1	0	0	0	0	0	0	1
Chromium	0	0	0	2	0	0	0	2
Cobalt	4	0	0	0	0	1	0	5
Copper	17	26	2	5	1	27	0	78
Gold	45	96	20	156	0	61	0	378
Iron	4	1	0	0	0	7	0	12
Lead	9	9	1	0	0	12	0	31
Magnesium	0	0	0	0	0	6	0	6
Manganese	0	2	0	1	0	0	0	3
Mercury	0	0	0	16	0	1	0	17
Molybdenum	8	8	0	1	0	5	0	22
Niobium	1	1	0	0	0	0	0	2
RE	2	0	0	0	0	0	0	2
Silver	28	25	1	5	1	16	0	76
Thorium	12	0	0	0	0	0	0	12
Titanium	2	0	0	0	0	0	0	2
Tungsten	5	1	2	4	1	5	0	18
Zinc	5	3	0	0	0	16	0	24
Totals	**144**	**174**	**27**	**192**	**3**	**159**	**0**	**699**
Rock Products								
Pumice	5	0	0	29	0	3	0	37
Stone	8	3	0	3	16	3	0	33
Totals	**13**	**3**	**0**	**32**	**16**	**6**	**0**	**70**
Energy Minerals								
Coal	1	0	0	1	0	20	0	22
Uranium	0	0	0	3	0	3	1	7
Totals	**1**	**0**	**0**	**4**	**0**	**23**	**1**	**29**
Industrial Minerals								
Aluminum	8	0	0	0	0	1	0	9
Barite	3	9	1	0	0	2	0	15
Calcium	0	0	0	0	0	20	0	20
Cinders	0	0	0	1	0	0	0	1
Clay	8	0	0	12	0	1	0	21
Diatomite	6	0	0	22	0	23	0	51
Feldspar	0	0	0	0	0	1	0	1
Fluorite	4	3	0	0	0	0	0	7
Garnet	2	0	0	0	0	0	0	2
Gemstone	4	0	0	0	0	0	0	4
Gypsum	3	0	0	0	0	0	0	3
Limestone	25	2	0	10	0	0	0	37
Peat	0	2	0	0	0	1	0	3
Perlite	1	0	0	13	0	0	0	14
Phosphate	20	14	0	0	0	0	4	38
Quartz Crystal	0	1	0	1	0	0	0	2
Sapphire	0	1	0	0	0	0	0	1
Silica	11	1	0	0	0	4	0	16
Sodium	0	0	0	2	0	2	0	4
Talc	0	0	0	0	0	1	0	1
Vermiculite	0	1	0	0	0	0	0	1
Zeolite	5	0	0	11	0	0	0	16
Totals	**100**	**34**	**1**	**72**	**0**	**56**	**4**	**267**

TABLE OF CONTENTS

Energy Resources

Geothermal Resources

Geothermal sites in the project area with temperatures greater than 50 °C and with significant resources are shown on Table 3. Developability rankings were assigned for important geothermal resources by Bloomquist et al. (1985). Ninety-six high temperature sites in four northwest states were ranked to indicate their likelihood for development. These subjective rankings consider factors such as heat content, completeness of data, land status and access, engineering criteria, population centers, and labor force. Developability rankings in Table 3 are generally grouped as good (1-19), average (20-79), or poor (80-96). Direct heat sources are not shown.

Table 3. Geothermal Resources with Potential for Development.

Area Name	Developability Ranking[1]	Est. Reservoir Temperature (°C)	Est. Reservoir Volume (km^3)	Mean Reservoir Thermal Energy (10^{15} BTU)	Electrical Energy (Mwe for 30 years)
		Hot water convection systems >150°C			
Idaho					
Crane Creek/Cave Creek	13	151-200	39.0	16.4	340
Big Creek Hot Springs	15	140-179	3.3	1.35	27
Blackfoot Lava Field	21	230	NA	NA	1,715
Rexburg Caldera	22	230	NA	NA	102,873
Nevada					
Hot Sulphur Springs	NR	144-184	3.3	1.35	27
Oregon					
Alvord Hot Springs	9	148-231	5.0	2.2	49
Newberry Volcano	14	180-280	47.0	27.0	740
Vale Hot Springs	16	152-161	117.0	45.0	870
Neal Hot Springs	28	173-210	3.3	1.6	36
Trout Creek Area	31	140-180	3.3	1.3	24
Borax Lake	34	165-231	8.3	4.0	91
Crumps Hot Springs	37	144-185	7.2	3.0	61
Mickey Hot Springs	40	180-227	12.8	6.5	160
Crater Lake Area	44	185	NA	NA	36,245
Washington					
Mt. Adams Area	33	NA	NA	NA	NA
		Hot-water convection systems 90-150°C			
Idaho					
Raft River	2	135-164	21	7.4	0.44
Newdale (Island Park Area)	91	84-122	89	20	1.22
Bruneau and Castle Creek Areas	NR	90-12	1,830	450	27
Montana					
Maryville	25	103-145	15	4.3	0.26
Oregon					
Lakeview Area and Barry Ranch	5, 6, 17	143-158	15.3	5.6	0.33
Klamath Falls Area	6	99-131	114.0	30.0	1.79
Klamath Hills Area	11	104-138	10.6	3.1	0.19
Mt. Hood Area	104	90-150	3.3	0.96	0.06
Summer Lake Hot Spring	NR	107-134	7.8	2.2	0.13

[1]See text NR=not ranked NA=Not applicable km=Kilometers

TABLE OF CONTENTS

In May 1995, Anadarko Petroleum Corporation announced an agreement to build the first geothermal-electric power generating station in the project area. Anadarko plans to bring on line in December 1998 a 22.9-megawatt (net) air-cooled, binary geothermal plant in southern Harney County, Oregon. Portland General Electric has agreed to buy and transmit the power to its 640,000 customers in the region. The plant, on the Borax Lake geothermal system near Fields, Oregon, will employ at least 50 people during construction and 20 people during operation. Estimated total revenues will be $13 million annually. The Borax Lake geothermal system lies 1000 feet deep and underlies 2.5 square miles of earth where the highest temperatures of 152 °C water originates.

Oil and Gas

Potential for discovering oil or gas deposits is excellent in the Moxa Arch Extension, Crawford-Meade thrust, Northern Wyoming Range, and Absaroka thrust plays. Estimated resources are shown on Table 4. Discovery potential is low and little activity is expected in the Columbia Plateau, Eldorado-Lewis, Disturbed Belt, and Snake River Plain. Exploration activity is limited by difficult topography and restricted access to public lands in the Eldorado-Lewis thrust, Moxa Arch Extension, and Northern Wyoming Range areas. In the Absaroka thrust play, seismic coverage is less than 10% in the poorly explored northern half of the play area, and it is here that future discoveries are most likely.

Table 4. Estimated Petroleum and Natural Gas Resources in the Interior Columbia Basin.

			Estimated resources (mean fractile)			
Location and Play	**Type**	**Area (mi[1])**	**Oil (MMbbl[1])**	**Gas (BCF[1])**	**Number of fields**	**Value[2] ($millions)**
Idaho						
Snake River Plain[3]	Natural gas	75,000	--	10	5	80
Crawford-Mead Thrust[3]	Natural gas	3,600	--	20	7	224
Wyoming						
Moxa Arch Extension[3]	Natural gas	1,000	--	600[4]	1	1,260
	Carbon dioxide			1,400		960
N. Wyoming Range[3]	Natural gas/Oil	5,200	10	60	30	8,655
Absaroka Thrust[3]	Natural gas/Oil	4,200	11	75	13	4,101
Washington-Oregon						
Columbia Basin[5]	Natural gas	7,500	--	1,000	1	1,600
Montana						
Eldorado-Lewis[6,7]	Natural gas	5,200	--	50	5	400
Disturbed Belt[6,7]	Natural gas	2,600	--	100	9	1,440

[1]MMbbl= million barrels; Bcf= billion cubic feet
[2]Value at $1.60/1,000 cu ft for natural gas and $19.25 for oil (Oil and Gas Journal, 1995)
[3]Peterson, 1993; Powers, 1993
[4]Resource is 70% CO_2 and 30% natural gas; CO_2 value is about half that of natural gas
[5]Tennyson, 1993
[6]Perry, 1993
[7]Perry and others, 1983

TABLE OF CONTENTS

Coal

No coal of any grade is expected to be mined from the project area, either from the surface or underground, in the foreseeable future. Deposits in the project area cannot compete with coal marketers outside the region, particularly those in Wyoming. Wyoming is the leading coal-producing state and currently exports coal to every other state in the project area (Energy Information Administration, 1992).

Bituminous coal of metallurgical grade in the western Roslyn field of Washington may have the greatest development potential. However, potential does exist for discovering economic quantities of methane from coal seams. Thick coal beds that are bituminous in rank are targets for coalbed methane exploration. Developing coal seams for coalbed methane production is simpler than mining because only boreholes and surface pipelines are needed to extract the resource. An accurate assessment of methane potential from coal fields in the project area is not available. The decade-old coalbed methane industry in the U.S. began because of recent technological developments but its growth has been modest due to competing low natural gas prices. The McDougal and Jackson Hole fields in Wyoming and Roslyn field in Washington offer some potential for developing methane from coal beds.

Mineral Development Interest Areas

Areas where development of mineral resources should be anticipated were composited from U.S. Bureau of Mines and U.S. Geological Survey favorable tracts data and rated for the likelihood that mining activity will occur (Map 1). Polygons were grouped for the 25 metallic deposit types expected in the project area; those rated high are areas where proposals for minerals exploration and development should be expected in the short term. In polygons rated moderate/high or moderate, minerals activity should be expected in the mid- to long-term time frame. The ratings are a function of (1) the number of active mining claims, (2) the number of producing metallic mines, (3) the number of past-producing metallic mines, (4) the number of significant mineral sites, and (5) the area of the polygon. Changes in commodity prices; market demand; mining, milling, or processing technologies; management practices; federal, state, and local laws and policies; and other variables will influence likelihood of mining activity.

For industrial minerals, continued mining activity should be anticipated in currently or recently active locations and in enclosing areas with similar geologic settings. For low unit-value construction materials (stone, sand, and gravel), demand will follow population trends and infrastructure improvements. Trade-offs between environmental and economic considerations will determine source locations for these commodities.

Undiscovered Mineral Resources

The economic effects stemming from development of as yet undiscovered mineral resources within the project area are potentially substantial. Engineering cost modeling was used to estimate these effects based on assessments of undiscovered resources by the U.S. Geological Survey (USGS). Undiscovered mineral resources include both new deposits and known occurrences for which no reliable information about location, quantity, and quality is available. The USGS assessed potential for undiscovered mineral resources in the “Northwest U.S.A.”, an area that includes the project area. This geologic assessment was used to estimate potential economic effects from development of those deposits. Estimates are based on the quantity and economic importance of minerals that could be produced under specified economic, technological, and land access conditions. This approach is probabilistic, reflecting the inherent uncertainty associated with

Map 1 - Areas favorable for mineral deposits where development activity is likely.

NOT AVAILABLE IN PDF

undiscovered mineral resources; its components and methodology are detailed in U.S. Bureau of Mines (1989).

Potential Supply Analysis was used to analyze the 25 metallic deposit types identified by USGS as likely to occur in the region. The USGS provided quantitative models describing the tonnages and grades for these deposit types and estimates of the number of deposits as yet undiscovered. U.S. Bureau of Mines estimated the portion of those undiscovered resources that are economically recoverable and the regional economic impacts their development would have. No attempt was made to quantify undiscovered resources of industrial minerals. These estimates are made for five different probability levels, 90%, 50%, 10%, 5%, and 1% exceedance. (That is, in the estimators judgment there is a 90% chance that the number of deposits will exceed that number, etc.) It should be noted that the existence of deposits does not imply that there is sufficient grade or tonnage to justify mining and milling at current or future commodity prices and mining and milling technologies.

Cost Models and Projected Development

Mine and mill cost models were developed, based on similar operations in similar environments, to estimate the capital and operating costs and percent of metals recovered for the different types of mines and mills which would be used to produce from these deposits.

While there are significant undiscovered mineral resources of many different deposit types, exploration is expected to concentrate on the top priority exploration targets. At current prices, the average number of economic deposits remaining in each of these terranes is: about one Alkaline Gold-Telluride, four Epithermal Vein-Comstock type, zero to one Epithermal Vein-Quartz Adularia type, one Hot Spring Gold-Silver, one Sedimentary Exhalative Zinc-Lead, one to two Gold Skarn, one Sediment Hosted Copper, and one Homestake Stratiform Gold. No economic deposits are expected of the Sediment Hosted Gold, Sediment Hosted Copper-Reduced Facies, or Massive Sulfide-Kuroko types. The total number of expected deposits, on average, is about twelve. If developed simultaneously these mines could be expected to generate more than 11,000 jobs, $770 million regional output, and $326 million income annually. These mines would ultimately produce 27 million troy ounces of gold, 698 million troy ounces of silver, 4 million tons of copper, 6.7 million tons of zinc, and 3.8 million tons of lead. If metal prices effectively doubled, about 33 deposits would be developed with comparable increases in jobs and outputs.

Environmental Considerations

Regulatory Setting

Although numerous laws and amendments are applicable to minerals management, four are of particular importance: the Mining Law (1872), the Mineral Leasing Act (1920), the Mineral Materials Act (1947), and the Mineral Leasing Act for Acquired Lands (U.S. Department of the Interior, 1993). The Mining Law designates most minerals “locatable,” providing for staking and patenting of mining claims. The total acreage, transferred through the patenting process as of 1992, was approximately 3.24 million acres, or 0.5% of 1% of total federal lands. The Mineral Leasing Act and the Leasing Act for Acquired Lands designated some minerals on public domain lands (notably energy and some non-metals), and all minerals on acquired lands as “leasable.” Finally, the Mineral Materials Act designates some “common” minerals as salable; in these cases, the land management agency may allow exploration and development through permits and sales.

TABLE OF CONTENTS

Not all federally owned land is open to mineral exploration and development. On some designated lands (wildernesses, wild river areas, and other special purpose categories) mineral and other activities are precluded or constrained in order to preserve special characteristics. Two significant other concerns complicate the management of mineral resources on public lands. First, valid existing rights to claims on withdrawn lands require review and adjustment of access and other activities in mining plans. Second, some lands have split ownership of surface and subsurface resources which must be addressed during management.

Public policy affects a decision to mine in a number of ways, most notably through land use and environmental restrictions. Particularly on public lands, policy over the last several decades has resulted in a reduction of the lands available for exploration and development. Other policies, including those listed below, have reduced options or increased the costs of mining. Finally, increasing demands for recreation and wilderness experiences will likely increase pressures to limit or prohibit future mining.

Since 1970, mining operations have been subject to regulations and reclamation standards that have stemmed primarily from federal environmental legislation. The cornerstones for federal regulations and standards are the National Environmental Policy Act (NEPA), the Clean Water Act, and the Clean Air Act. Regulations were developed to prevent present and future mining operations from posing the same environmental liability as past mining practices; the effectiveness of regulations to adequately protect human health and the environment is unproven. Numerous state and local regulations are as restrictive as federal requirements or more so. A partial listing of current federal environmental legislation and programs that may apply to today's mining operations includes:

- National Environmental Policy Act (NEPA)
- Clean Water Act (including National Pollutant Discharge Elimination System, Section 404-Dredged and Fill Material Permit, Non-Point Source Program, and Oil and Hazardous Substances Spill Program)
- Clean Air Act (including General Air Quality Permit, Prevention of Significant Deterioration Program, and Non-Attainment Program)
- Safe Drinking Water Act (including Underground Injection Program)
- Endangered Species Act
- Migratory Bird Treaty Act
- Toxic Substance Control Act
- Emergency Planning and Community Right-to-Know Act
- Mine Safety and Health Act
- Occupational Safety and Health Act
- Historical and Archaeological Data Preservation Act
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
- Resource Conservation and Recovery Act (RCRA)

In addition to providing for reclamation at contaminated sites, CERCLA has been a significant deterrent to parties (in both the public and private sectors), who might otherwise attempt site cleanups. As currently implemented, site operators performing remediation are considered "responsible parties" under CERCLA and therefore potentially liable for all past activity and future releases from the site. As a result, to date relatively few abandoned mine sites with chemical hazards have been reclaimed.

Reclamation Costs

Under existing provisions of the Clean Water Act and other laws, one of the most certain types of mineral economic activity will be the remediation and reclamation of abandoned mine and mineral processing sites. Such sites exist throughout the nation, but are concentrated in the Western

States. As discussed above, there are almost 14,000 sites in the project area with hundreds likely to require remediation. The expenditures required for these activities, while uncertain, will have local and regional economic impacts.

The primary uncertainties in the remediation and reclamation of abandoned and inactive mines are the costs and standards for cleanup, two complex and intertwined topics. The technologies for addressing physical hazards are relatively well-known and straightforward, but those applicable to chemical problems are more problematic. The central and mostly unanswered questions are: how “clean” is clean enough; is a technology available for achieving a particular standard; what are the short and long term cost implications; and who will pay for remediation or for developing the required technologies?

The complexity of the rehabilitation process makes modeling of remediation costs especially tenuous. For sites with chemical hazards, site specific conditions present many unknowns and independent variables that can have dramatic effects on costs. Generalized state-level projections and cost estimates for completion of remedial actions at abandoned and inactive mine sites show the degree of uncertainty for remediation costs associated with chemical hazards; some are separated by orders of magnitude (Table 5).

Table 5. State Estimates of Mined Land Remediation Costs[1]

State	Remediation costs[2]	Comment
Idaho	$315,566,900	Total remediation costs
Montana	$912,280,000	Total remediation costs including Superfund sites.
Nevada	$2,529,000	Total remediation cost for hazardous mine openings; does not include chemical hazards
Oregon	$57,000,000 to $77,000,0000	Total remediation costs
Utah	$174,790,000	Total remediation costs
Washington	None available	Did not participate in survey
Wyoming	$45,000,000	Total remediation costs

[1]Western Interstate Energy Board, 1991
[2]General costs are estimated at $1,000,000 per mile for high impact polluted waters and $30,000 per acre of mine dump.

The range of costs for specific aspects of reclamation are shown in Table 6; those for addressing physical hazards are fairly well known while those for addressing chemical contamination reflect considerable uncertainty.

TABLE OF CONTENTS

Table 6. Reclamation Cost Estimates

Disturbance type	Reclamation cost estimates Low ($)	High ($)	Comments
Mine openings (per opening)	400	5,350	Range of costs represent different techniques and economies of scale
Structures (per structure)	400	4,000	Same as above
Highwalls (per mile)	50,000	100,000	Based in part on coal and construction reclamation experience
Disturbed land (per acre)	1,500	10,000	Most estimates are under $3000; higher costs are specific to uranium reclamation
Polluted surface water (per mile)	30,000	1,000,000	The wide range of costs suggests low confidence in estimates and lack of experience in reclamation
Mine dumps (per acre)	2,500	30,000	Same as above

Source: U.S. Bureau of Mines and Colorado Center for Environmental Management, 1994

In 1988, the Government Accounting Office estimated that 424,049 acres of federal land were unreclaimed as a result of hard rock mining in 11 western states. The abandoned area covers about 281,581 acres and the estimated cost to reclaim these acres is $284 million or $1,000 per acre.

GO TO APPENDIX 2-2

GO TO APPENDIX 3-1

TABLE OF CONTENTS